VQ4. Changes in and Responses to Disturbance

How are disturbance regimes changing and how do these changes affect the ecosystem processes that support life on Earth?

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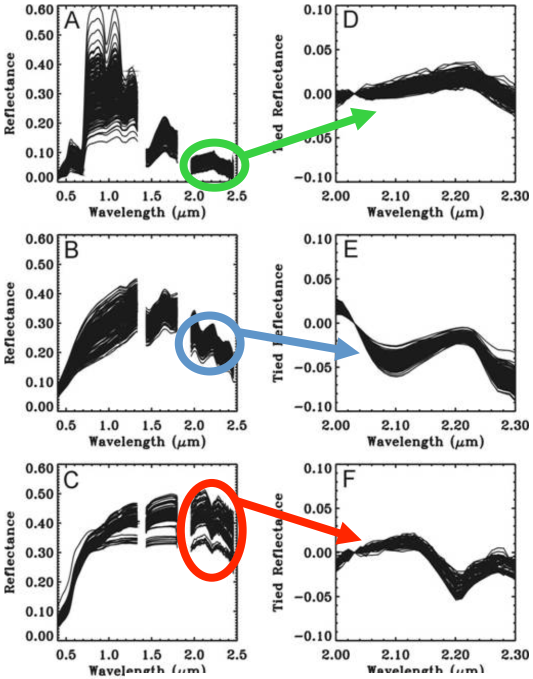
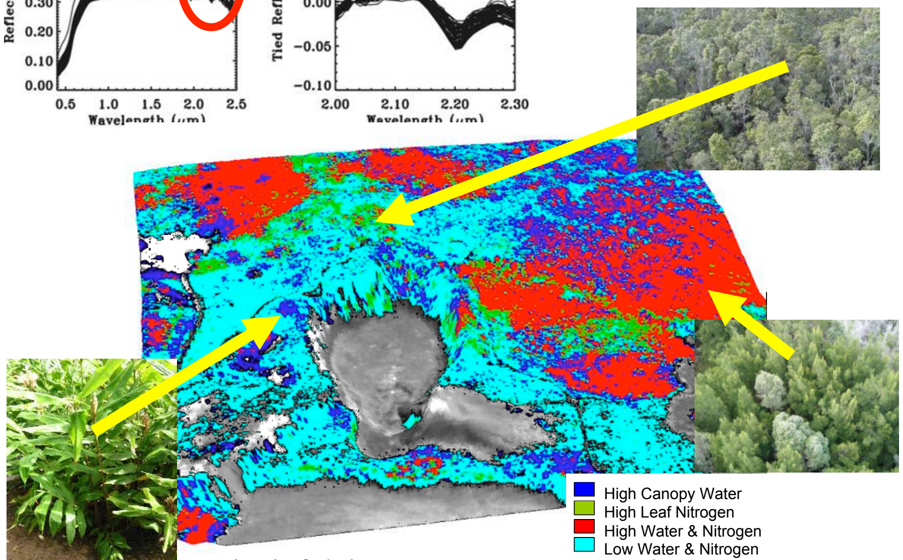


Left: High-fidelity shortwave-IR measurements are key to mapping diffuse disturbances in ecosystems.

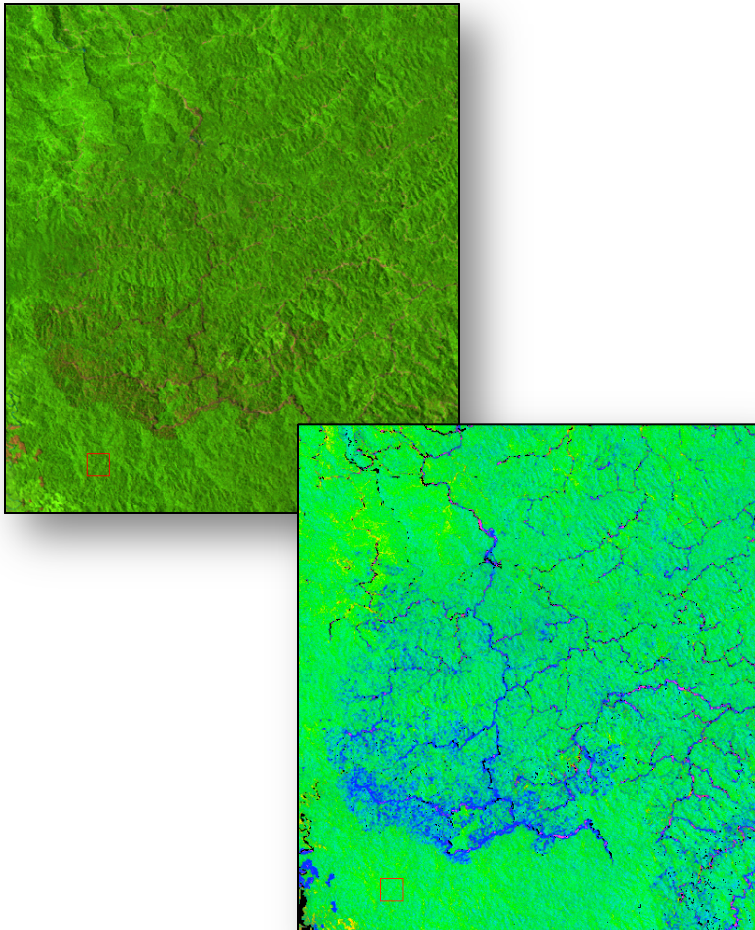
(A, D) Live vegetation;
(B, E) Dead vegetation;
(C, F) Mineral soils



Above: Full-range, high-fidelity spectroscopy provides measurements of canopy chemicals which often indicate changes in species composition. Here, these changes are associated with disturbance caused by plant invasions

- ***Science Issue***
  - We can identify major disturbances such as tropical deforestation, and some diffuse disturbances (some logging, some fire, some insect outbreaks), but current missions are not specifically resolving the diffuse disturbances with high biophysical, process-oriented fidelity. We need to step from our current state – identifying an important process or change to quantifying the ecological effects of the event.
- ***Tools***
  - Periodic measurement of the contiguous spectral signature from 400 to 2500nm at 10 nm spatial sampling at 60 m with high signal-to-noise ratio and with excellent spectral and IFOV uniformity.
- ***Approach***
  - Measure the spectral properties of ecosystems over time.
  - Use spectral signature based algorithms and modeling approaches to convert spectra to structural and chemical properties of ecosystems.
  - Accurate atmospheric characterization and correction is a critical enable requirement.

VQ4a. How do patterns of disturbance vary and change over time within and across ecosystems?



Hyperion’s spectral measurements from the NASA EO-1 technology demonstration mission reveal rainforest disturbance caused by logging and fire.

Science Issue:

Natural and human-driven disturbances are not rare occurrences in ecosystems; they are the norm. Disturbances such as storms, mud slides, water spouts, fire and insect outbreaks shape ecosystems and the flow of materials between terrestrial and aquatic realms, yet it remains difficult to resolve the responses of ecosystems to these and many other types of disturbance. Biophysical and chemical attributes of ecosystems change with and respond to disturbance, thus large-scale measurements of key parameters such as fractional material cover, nutrients and water properties can reveal changing disturbance patterns over time.

Tools :

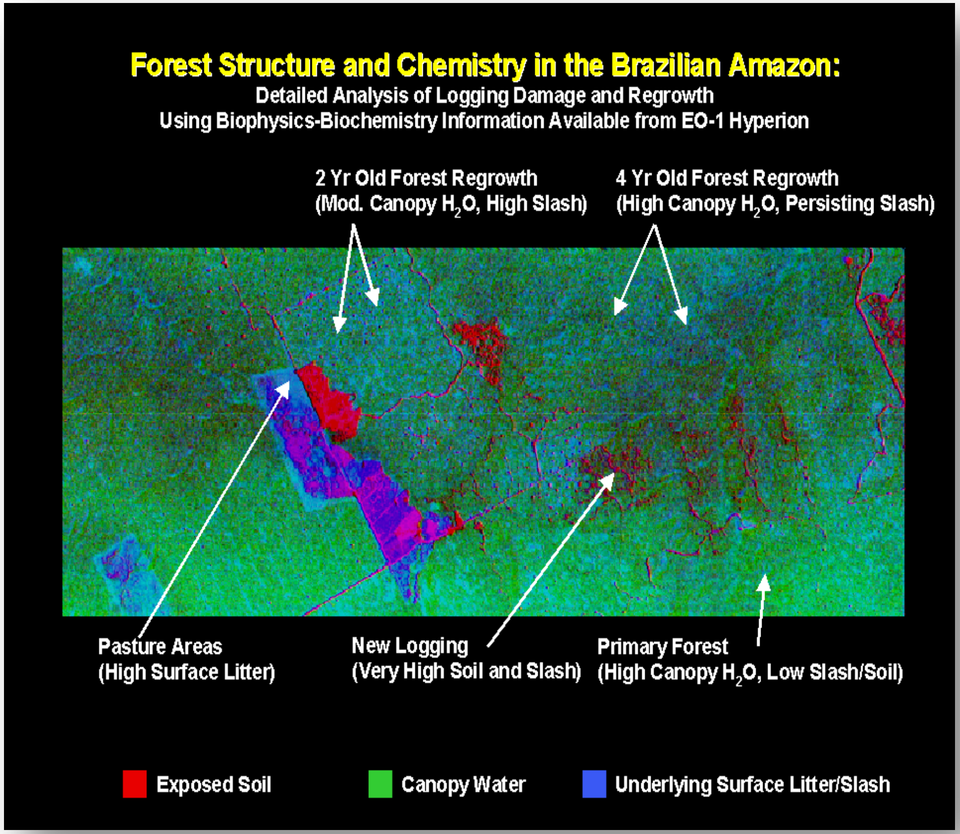
Spectral measurements from HyspIRI covering the 400 to 2500 nm wavelength range at 10 nm intervals (terrestrial); 380 to 900 nm at 10nm intervals (aquatic)

- 95% spectral cal uniformity
- SNR 600 VNIR, 300 SWIR (23.5ZA 0.25R)
- 14 bit precision: >95% abs cal: > 98% on-orbit stability
- no saturation of ecosystem targets
- < 2% polarization sensitivity 380 to 700 nm
- > 99% linearity 2 to 98% saturation
- ≤ 60 m spatial sampling
- > 95% spectral IFOV uniformity
- < 20 day revisit to minimize cloud obscuration

Approach:

- Measure the spectral properties of ecosystems over time.
- Use spectral signature-based algorithms and modeling approaches to convert spectra to structural and chemical properties of ecosystems.
- Accurate atmospheric characterization and correction is a critical enable requirement.

VQ4b. What are the trends in disturbance regimes, compared with previous regional and global observations?



Spaceborne imaging spectrometer measurements, such as from EO-1 Hyperion, reveal functional responses of forests to natural and human-caused disturbance.

Science Issue:

We can identify major disturbances such as tropical deforestation, and some diffuse disturbances (some logging, some fire, some insect outbreaks), but current Earth observing missions are not specifically resolving the millions of diffuse disturbances with high biophysical, process-oriented fidelity. We need to step from our current state – identifying an important process or change to quantifying the ecological effects of the disturbance events that occur dynamically throughout ecosystems of the world.

Tools:

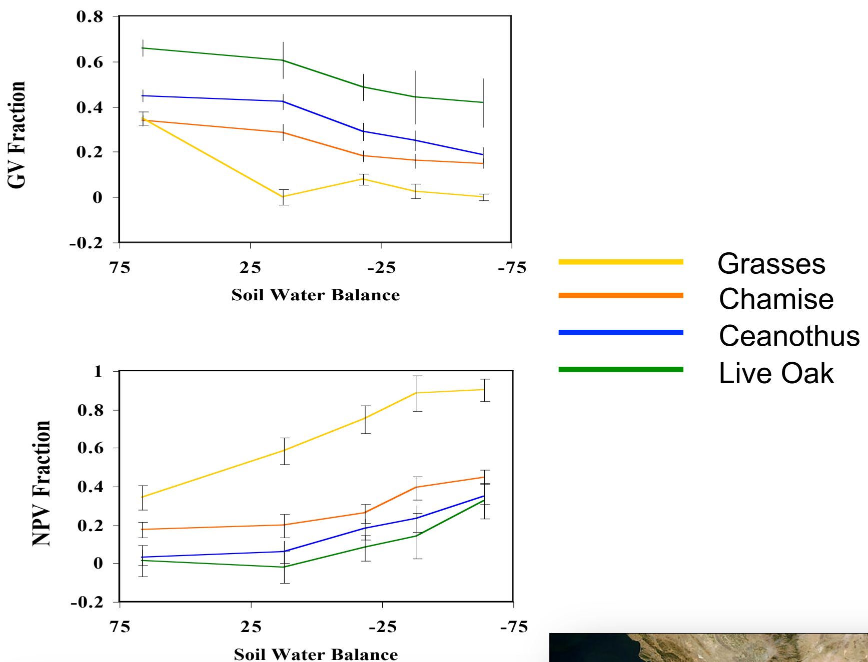
Spectral measurements from HyspIRI covering the 400 to 2500 nm wavelength range at 10 nm intervals (terrestrial); 380 to 900 nm at 10nm intervals (aquatic)

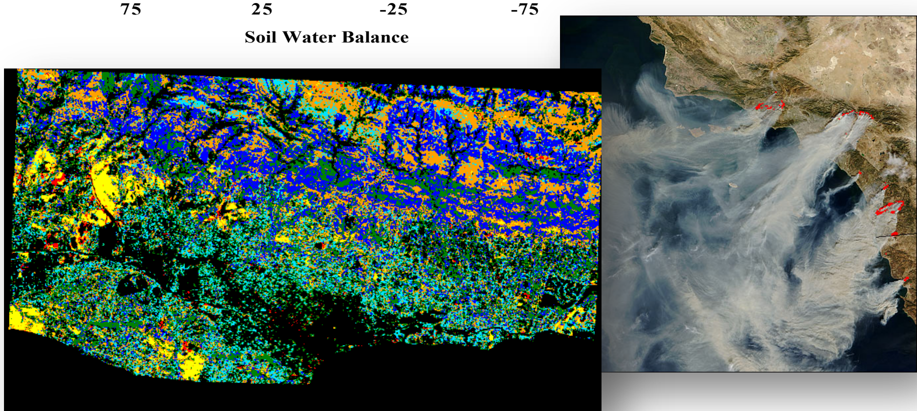
- 95% spectral cal uniformity
- SNR 600 VNIR, 300 SWIR (23.5ZA 0.25R)
- no saturation of ecosystem targets
- < 2% polarization sensitivity 380 to 700 nm
- > 99% linearity 2 to 98% saturation
- < 60 m spatial sampling
- > 95% spectral IFOV uniformity
- < 20 day revisit to minimize cloud obscuration

Approach:

- Measure the spectral properties of ecosystems using high-fidelity imaging spectrometer.
- Use spectral signature-based algorithms and modeling approaches to convert spectra to structural and chemical properties of ecosystems.
- Accurate atmospheric characterization and correction is a critical enable requirement.

VQ4c. How do climate changes affect disturbances such as fire and insect damage? [DS 196]





NASA AVIRIS provided mapping of species and plant functional groups that respond differently to rainfall (soil water), which affects fire proneness in southern California.

Science Issue:

Disturbances do not occur in a vacuum, as many types of disturbance are spatially and temporally interconnected. Disturbances such as fire and insect outbreaks are thought to significantly impact ecological dynamics including biogeochemical cycles, yet these disturbances are often tied to changes in climate. Resolving these interactions at large scales requires spatial observations of vegetation and ecosystem responses to multiple disturbances and climate change.

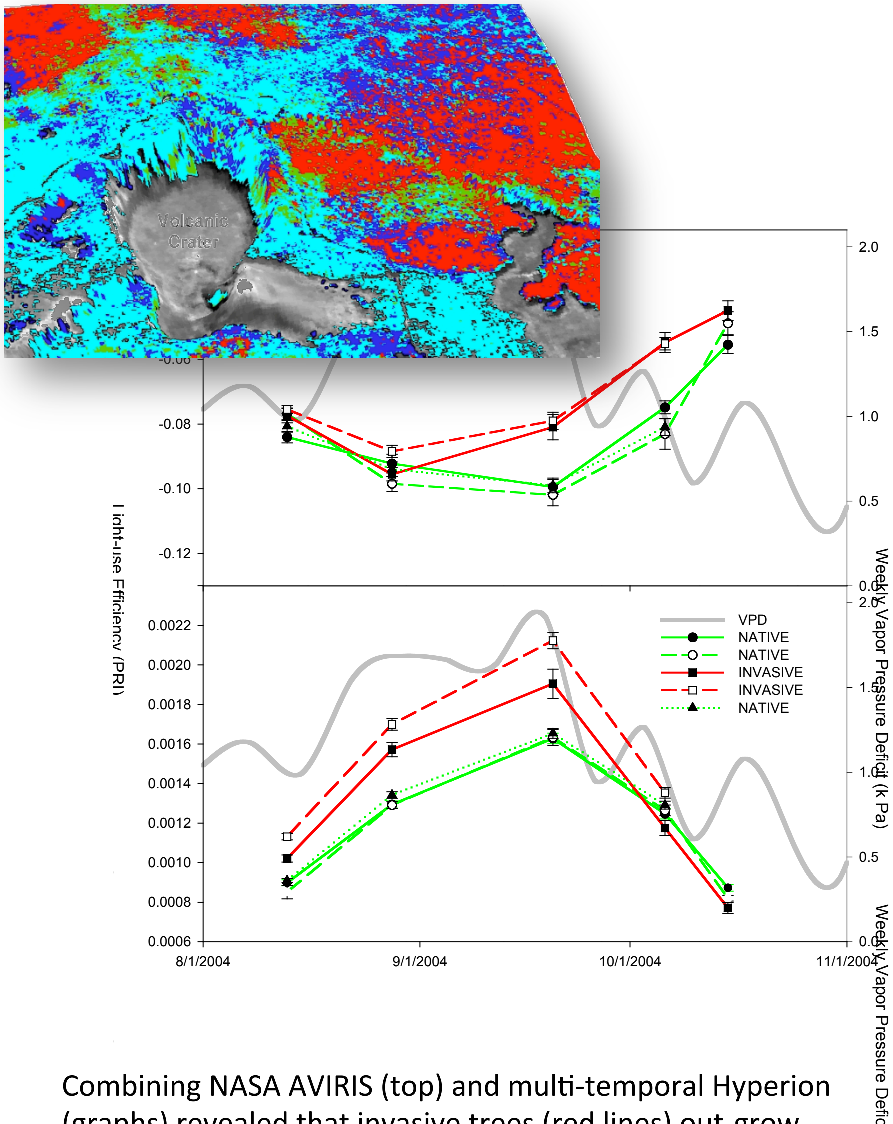
Tools :

- Multi-temporal measurements from HyspIRI covering the 400 to 2500 nm wavelength range at 10 nm intervals
- Spectral libraries of plant functional types
- Regional (mesoscale) ecosystem and climate models

Approach:

- Measure the spectral properties of ecosystems over time.
- Use spectral signature-based algorithms and modeling approaches to convert spectra to plant functional types (often species) and biochemical information.
- Combine data derived from HyspIRI with data from climate sensors and models.

VQ4d. How do climate change, pollution and disturbance alter the vulnerability of ecosystems to invasive species? [DS 114,196]



Combining NASA AVIRIS (top) and multi-temporal Hyperion (graphs) revealed that invasive trees (red lines) out-grow native trees (green lines) during periods of climate stress (gray line)

Science Issue:

Invasive species are both a cause and consequence of ecological disturbance. Climate change, air and water pollution, and physical disturbance can alter the vulnerability of ecosystems to the introduction and proliferation of invasive species. Spatially extensive, multi-temporal information is required to quantify, track and understand how human activities change the distribution of invasive species at regional and global scales.

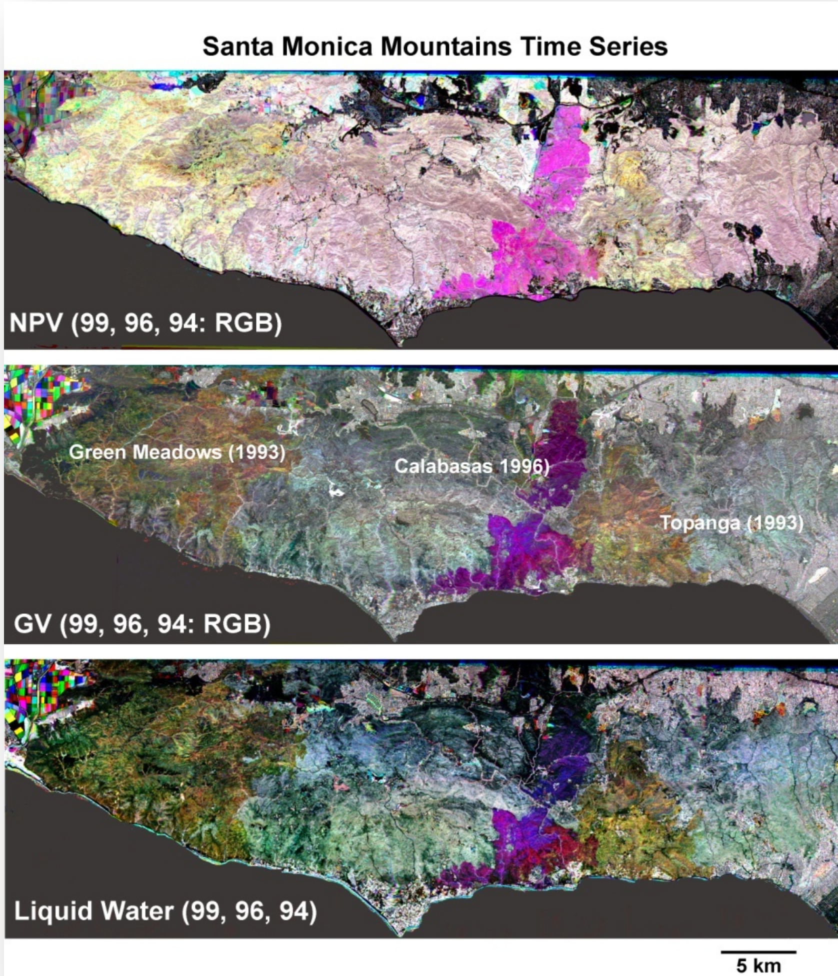
Tools :

- Multi-temporal measurements from HyspIRI covering the 400 to 2500 nm wavelength range at 10 nm intervals (terrestrial); 380 to 900 nm at 10nm intervals (aquatic)
- Ground network and atmospheric measurements of climate variables, pollutant concentrations, winds, etc.
- Spectral libraries of plant functional types and key invasive species
- Regional (mesoscale) climate models

Approach:

- Measure the spectral properties of ecosystems over time.
- Use spectral signature-based algorithms and modeling approaches to convert spectra to plant functional types (often species) and spectral-biochemical metrics of vegetation growth and mortality.
- Combine data derived from HyspIRI with data from climate sensors, ground observation networks, and models.

VQ4e. What are the effects of disturbances on productivity, water resources, and other ecosystem functions and services? [DS 196]



NASA AVIRIS mapped fire disturbance and changes in vegetation water content in Southern California.

Science Issue:

Disturbance affects the productivity, carbon storage, water quality and quantity, and many other services provided by ecosystems to society. The type, spatial pattern, intensity and rates of disturbance are critical determinants of changing ecosystem functions and services. Pathogen and pest outbreaks, vegetation removal, fire, and water diversion are examples of non-land cover changing disturbances. Spatially explicit monitoring of vegetation and soil physical and chemical properties provide quantitative measures of how ecosystem services are changing with disturbance.

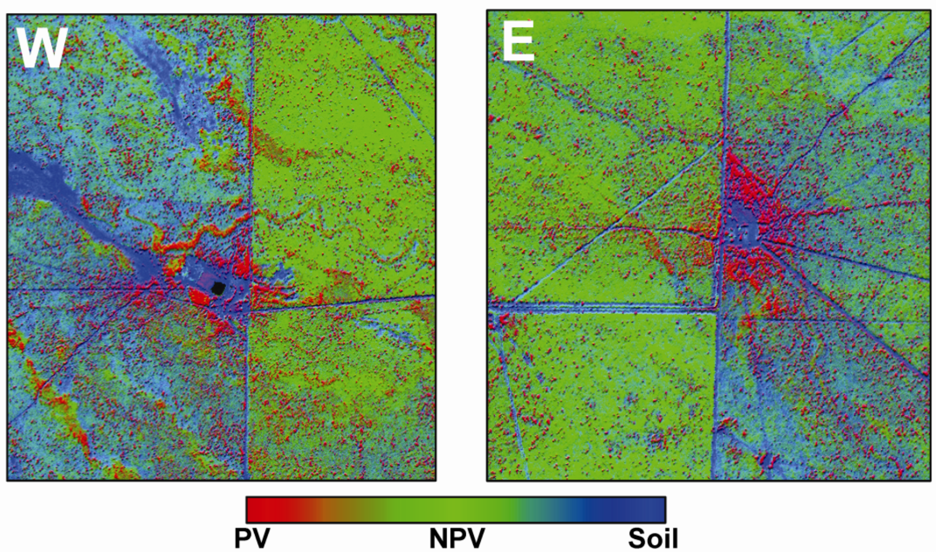
Tools :

- Multi-temporal measurements from HyspIRI covering the 400 to 2500 nm wavelength range at 10 nm intervals (terrestrial); 380 to 900 nm at 10nm intervals (aquatic)
- Models simulating the flows of ecosystem services at landscape and regional scales.

Approach:

- Measure the spectral properties of ecosystems over time; detect and identify disturbance events
- Use spectral signature-based algorithms and modeling approaches to convert spectra to assess vegetation, soil and ecosystem responses to disturbance.
- Combine data derived from HyspIRI with ecosystem models to simulate changes in carbon, nutrient, and water cycles during and following disturbance.

VQ4f. How do changes in human uses of ecosystems affect their vulnerability to disturbance and extreme events? [DS 196]



NASA AVIRIS mapped changes in the fractional cover of live, photosynthetic vegetation (PV), dead non-photosynthetic vegetation (NPV) and bare soil following construction of a fence to exclude cattle grazing from ecological sensitive desert ecosystems in Argentina.

Science Issue:

Environmental management decisions play a major role in determining the vulnerability of ecosystems to disturbance as well as the susceptibility of ecosystems extreme events such as drought or flooding. Large-scale monitoring and assessment of land-use decisions requires observations that resolve ecosystem changes beyond those related only to land-cover change. HyspIRI will provide observations that resolve plant functional types, nutrient stocks and water properties indicative of ecosystem response to and feedbacks with disturbance.

Tools :

- Multi-temporal measurements from HyspIRI covering the 400 to 2500 nm wavelength range at 10 nm intervals (terrestrial); 380 to 900 nm at 10nm intervals (aquatic)

Approach:

- Measure the spectral properties of ecosystems over time; detect and identify disturbance events
- Use spectral signature-based algorithms and modeling approaches to convert spectra to assess vegetation, soil and ecosystem responses to disturbance.